SCIENCE IN ACTION- JANUARY 2007

Here is a brief description of the experiments that were set up at the annual 'Science In Action' By Bangalore Association for Science Education (BASE) at Jawaharlal Nehru Planetarium between January 19 and 21, 2007. You may contact us for any help in setting up these experiments.

Parabola Of Rotation

Objective: To show that the surface of water curves when set into rotation.

Experiment: Water if filled in a narrow container and placed on a rotating platform. The surface of water is seen to be stretched into a thin sheet. Now, spin the platform. Water in the container is no longer a flat surface that it was. The surface is drawn into a parabola.

Reason: The surface in a spinning container takes the shape of a parabola because water experiences an 'artificial gravity' due to the centrifugal force whose magnitude depends on the speed of rotation. Greater the speed of rotation, larger is the 'gravity'. This tends water to move away from the centre. But, the walls of the container constrain the motion. As a result, water along the edge rises causing the level at the centre to drop, giving a parabolic shape.

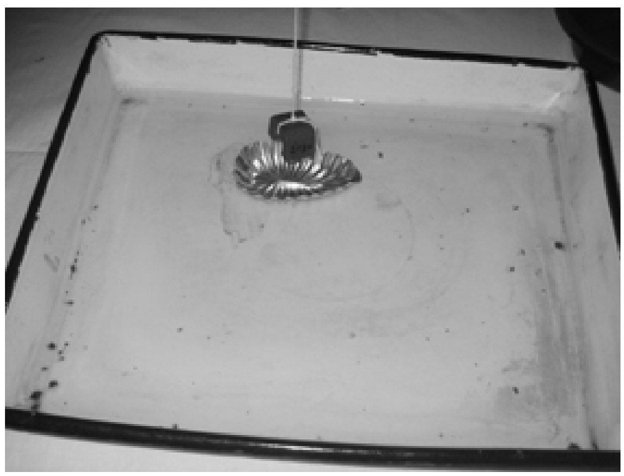
Invisible Flicker

Objective: To illustrate that gas discharge lamps produce light beyond a certain voltage

Method: Take a small neon bulb with a one kilo ohm resistor connected in series with it. Such bulbs are readily available in electrical shops. Connect the bulb across the wires of a flexible power cord. Plug the other end of the cord into the AC mains supply. The neon bulb glows. Now, hold the cord about one metre from the bulb and whirl it. You will observe arcs of light broken at regular intervals.

Reason: A neon bulb of this kind requires about 65 volt to ionize the gas and produce light. Since the power supply is an alternating voltage, the voltage goes from zero to 220 volt. And, the AC frequency is 50 hertz. So, there will be periods in the ac supply when the voltage is below 65 voltage. That is when the bulb does not glow!

Rotating Boat



Objective: To illustrate Lenz's Law

Method: Place an aluminium boat in a bowl of water. Also, suspend a horseshoe magnet from a string. Hold the free end of the string in one hand and rotate the magnet. Bring the rotating magnet near the aluminium boat. The boat also rotates!

Reason: The rotating magnet produces a changing magnetic field. As it is brought close to the aluminium boat, current is induced in the boat which give rise to a magnetic field that opposes the motion of the magnet - in accordance with Lenz's Law. This is the principle behind the working of speedomaters.

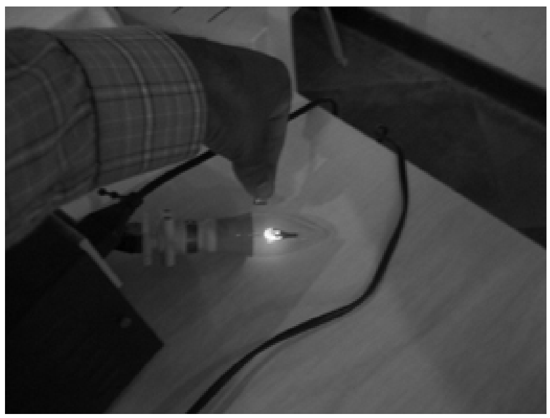
Disappearing Image

Objective: To demonstrate Brewster's Law of Polarization of light

Experiment: Project a slide from a slide projector on to a glass plate (alternately, a burning candle may also be used). Reflect the image off the glass plate onto a screen. Place a polaroid sheet between the glass plate and the screen. Now, as we slowly change the angle of the plate with respect to the incident light, at one angle the image on the screen disappears!

Reason: When the angle of incidence on the glass plate is equal to about fifty seven degrees, the reflected will be completely polarized. The polaroid sheet is kept at right angles to the polarization of the reflected light. As a result, light does not pass through it and the image disappears.

Putting Out A Neon Bulb With A Magnet

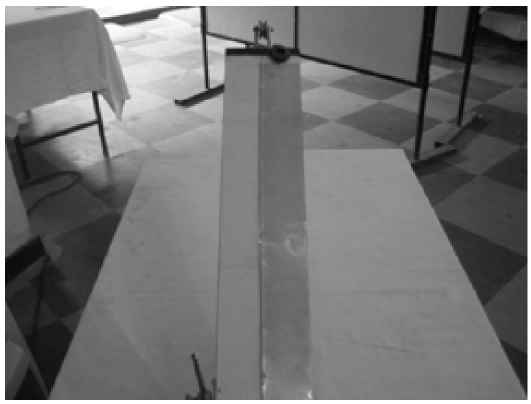


Objective: To show that a magnet affects the motion of ions.

Experiment: Use the small neon bulb with a resistor that was used in one of the earlier experiments. Use a variac to supply just about 65 volts so that the neon bulb just about glows. Now, bring a magnet close to the bulb and the bulb goes 'off' !

Reason: The neon bulb is a gas dicharge bulb. The gas present in it is ionized by the current supplied to it. When we bring a magnet near it, the ions issuing out of one electrode are deflected by the magnetic field. Hence, they do not reach the other electrode and the light goes 'off'.

Sliding Lazy Magnet



Objective: To demonstrate Lenz's law

Experiment: Keep a piece of wood with a smooth surface in an inclined position. Place a strip made of aluminium on one half of the wooden surface and leave the other half as it is. Now, cover the two halves with transparency (the ones used for OHP presentations) sheets in order to have identical smoothness of the surfaces in the two halves. Now let two identical 'ring' magnets slide on the two halves. You will observe that the magnet on the aluminium half moves very slowly compared with its counterpart on the wooden half.

Reason: The magnet sliding on aluminium induces currents in it which reduces the acceleration of the magnet in accordance with Lenz's Law.

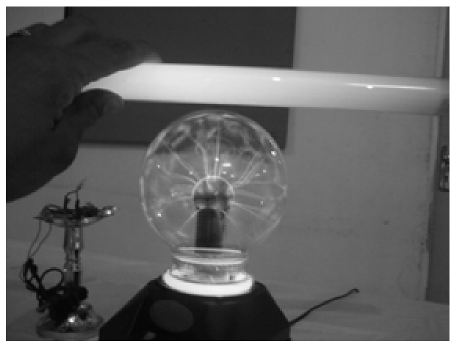
Falling Chimney Paradox

Objective: To show that in certain situations some bodies may have acceleration greater than that of 'g'.

Experiment: Hinge a rod or a wooden plank to a baseboard. Place a peg at the free end of the hinged board. Place a small ball on the peg. A small distance down along this board, place a cup. Now, gently lift the free end of the hinged board by some angle and release it. The ball would have fallen into the cup, if the angle of inclination were just about right.

Reason: The moment the hinged board is released, the ball has a free fall. The cup, however, is not under free fall due to the torque of the board. In fact, it will have an acceleration greater than that of 'g'. That is why, the cup comes right below the ball. The centre of mass of the hinged board would still be falling with acceleration `g`.

Plasma Globe

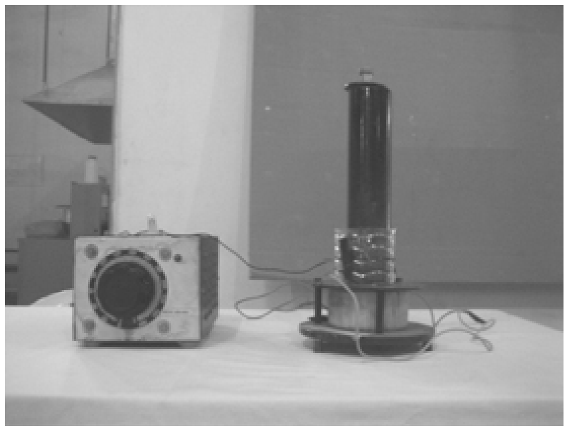


Objective: The 'Plasma Light' available in several fancy stores is a source of ions.

Experiment: 'Plasma Light' is a fancy item used for decorative purposes and available in several fancy stores. It is a wonderful source to demonstrate several principles. Here, we show one of them. Switch the plasma light on. Bring a neon bulb or a tube light not connected to the main supply near it. The bulb / tube light glows.

Reason: The 'Plasma Light' is filled with an inert gas. It is ionized by a high frequency of the power supply built into it. The ions formed inside stream out of the glass bulb and collide with gas atoms in the neo bulb or tube light. The collision ionizes the gas inside the bulb and the bulb glows.

Variable Transformer



Objective: To illustrate that the ac voltage induced in the secondary of a transformer depends on the number of turns in it

Experiment: Wind a two thousand-turn coil with enamelled copper wire on a PVC pipe. This is the primary of our transformer. Insert soft iron rods into the pipe that function as the core. Next, take a very long piece of copper wire - long enough to wind about twenty turns around the PVC pipe, and connect its two ends to a 3v bulb. Now, wind, the wire connected to the bulb around the PVC pipe. After a certain number of turns, you will observe that the bulb just about begins to glow and also that the glow gradually brightens up with each turn.

Reason: In a transformer, the product of input voltage and the number of turns in the secondary is equal to the product of the number of the turns in the primary and the voltage induced in the secondary. Consequently, the induced voltage increases with the number of turns and the bulb glows with increasing brightness.

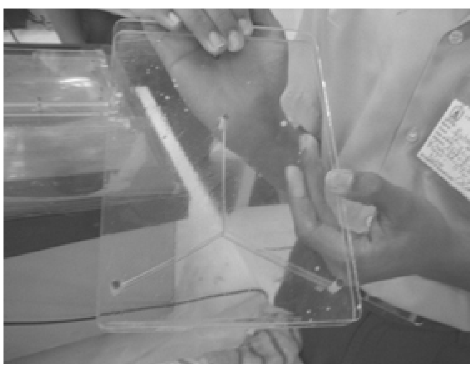
Non-burning paper

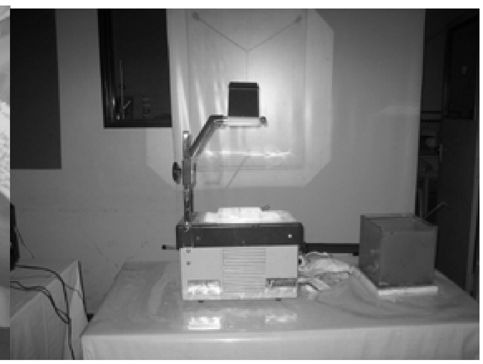
Objective: To show that a piece of paper burns only above its ignition temperature

Experiment: Take a mixture comprising 25 cc each of ethyl alcohol and water. Soak a piece of paper in this mixture and light it up. Burning flame is clearly visible but the piece pf paper remains unburnt!

Reason: The ignition temperature of alcohol is less than that of paper. So, it catches fire immediately. As long as it burns, the heat is used up in raising the temperature of water. Hence, the piece of paper never reaches its ignition temperature until all the water has evaporated.

Motorway Problem



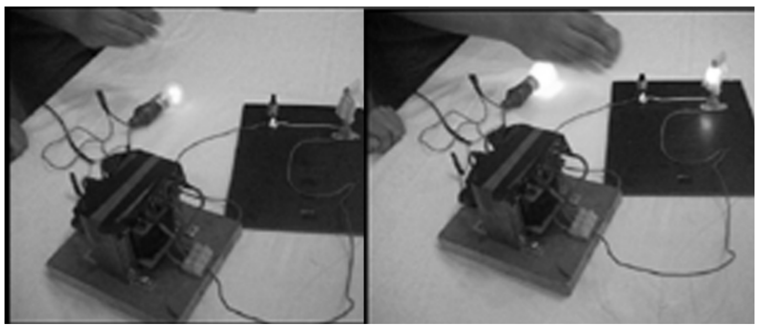


Objective: To connect a certain number of points in the most economical way.

Experiment: Cut two identical pierces of acrylic sheets - 10 cm X 25 cm - is a good size. Use screws as spacers to keep the two sheets parallel and one above the other. The spacers are our 'points' to be connected. Now, dip the acrylic frame into a soap solution. On removing the frame, we see that the soap film would have connected all the 'points'. And, that manner of connecting would be the most economical one!

Reason: Energy is needed to form and sustain soap films. So, films are formed in a manner that requires least expenditure of energy. This can happen only if the total length of the film connecting the points is smallest.

Transformer



Objective: To demonstrate that the current flowing in the primary of a transformer depends on the load in its secondary

Experiment: Use a step down transformer for this experiment - a 220v to 9v transformer will do. Connect a 15 watt ('zero candle') bulb in series in the primary of the transformer. When the current is switched 'on' the bulb glows. Now connect a 6v motorcycle bulb across the secondary. The bulb in the secondary glows and the bulb in the primary glows brighter than before.

Reason: When there is no load in the secondary, the primary current is decided by the reactance of the coil in the primary. As soon as we connect a bulb in the secondary, that is, offer some load, more current is drawn in. hence the bulb in the primary now glows brightly.

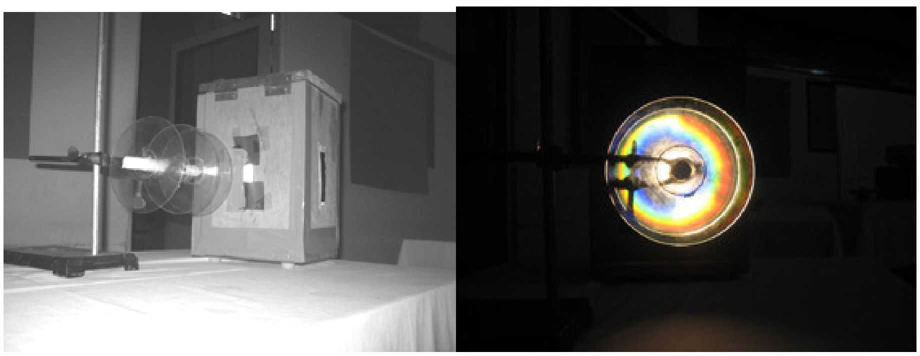
Surface Tension

Objective: To demonstrate the surface tension in soap films

Experiment: Take a circular frame made of a thick wire. Tie a string along the diameter of the circular frame. Now dip the frame in a solution of soap. A film spanning the frame will be formed. Suppose we break the film on one side of the string, we observe that the string is pulled up into an arc of a circle.

Reason: As soon as the film on one side of the string is broken, the tension in the film pulls the string up. The tension is pretty large. This we can infer by suspending a weight on the string. The film can withstand about 20g!

Artificial Corona

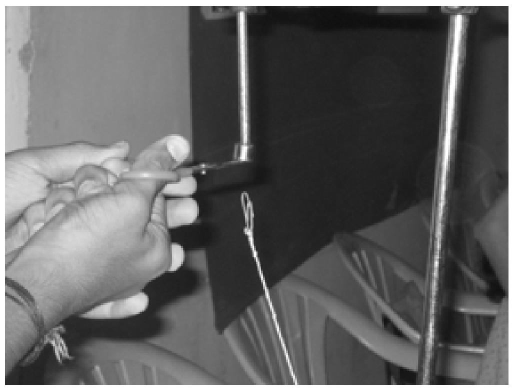


Objective: To demonstrate diffraction of light by a compact disc (CD)

Experiment: A CD has two surfaces - one that has a label and the other that is clear. Peel off the label carefully with the help of a pen knife. Now, place the centre of the CD near the flame of a candle or a bulb. Do not take it too close - it may melt. Look at the centre of the CD as you make slight adjustment in its distance from the light source. At a suitable distance, you will observe circular spectra that resembles the colours of corona around the moon

Reason: A CD has a number of closely spaced grooves that act as diffraction grating. Light waves passing through such grooves bend. The extent of bending depends on the wavelength. Hence, light of various wavelengths separate out into different colours.

'Cutting' Line of Force



Objective: To show that magnetic lines of force do not penetrate through iron

Experiment: Clamp a strong magnet to a lab stand. Tie a string to a paper clip. Tether the free end of the string onto the table. Take the paper clip up near the magnet so that the paper clip is attracted by the magnet but with a gap between the two. Now take a pair of scissors in the gap and pretend to cut the lines of force. The clip falls down!

Reason: The clip is held by the magnetic force acting on it. The moment we introduce the scissors made of iron, the lines of force are shunted through it and the filed experienced by the clip will be too weak to hold it in place. This is the principle on which magnetic keepers work.

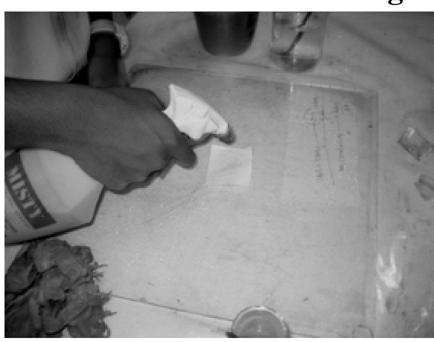
'Unmixing' Liquids

Objective: To show that the mixing of two viscous fluids do not happen instantaneously

Experiment: Take glycerine in a transparent beaker. Place a cylinder inside the beaker such that it can rotated without disturbing the beaker. Squirt a drop of sketch pen ink into glycerine. The ink drop forms a 'line' and does not mix with glycerine. Now, rotate the inner cylinder, say ten rotations. You will observe that the ink is dragged along and it would have 'mixed' with glycerine. Next, rotate the inner cylinder in the opposite direction and by the same number of turns. The ink drop would have almost returned to its initial shape!

Reason: Glycerine is a highly viscous (thick) liquid. Rotations of the inner cylinder would set the molecules into motion random enough to spread out the molecules of ink throughout it.

Magic Writing



Chemicals: Ferric chloride and potassium thiocyanate solution.
Apparatus: Ink pens, spray bottles and beakers
Method: Prepare dilute solution of ferric chloride in a spray bottle. Fill the ink pens with potassium thiocyanate solution. Write a message on a sheet of paper. Now, spray ferric chloride solution on the message.
Observe: A coloured message appears on the sheet of paper.
Reason: Potassium thiocyanate reacts with ferric chloride to form a deep red ferrous thiocyanate.

Water Projectile

Materials Required: A pipe of about one metre closed at one end.

Experiment: Make three holes – one at the 25 cm mark, another at 50 cm and the third at 75 cm. Stopper the three holes and fill the pipe with water and ensure a continuous supply of water into the pipe so that the pipe is always filled with water to its brim. When the stoppers are removed which of the holes will throw water to a maximum horizontal distance? Contrary to the popular notion, the middle one throws the maximum distance!

Explanation: The horizontal distance that water covers is decided by both the distance of the hole from the bottom as well as from the top. In fact, the product of these two distances decides the range covered by water. And, the product is maximum for the hole in the center of the pipe.

Colourful Corn Syrup

Materials Required: two polaroid sheets, corn syrup, source of light

Experiment: To start with, the light from a source such as a slide projector is projected on to a screen. A polaroid sheet is placed in the slide holder. Corn syrup is taken in a beaker and placed in front of the polaroid. The intensity of the light on the screen is diminished. Now, if another polaroid is placed between the observer and the beaker, one can see a change in the colour of the emerging light. As one of the polaroids is rotated, various colours can be seen.

Corn syrup is made up of sugar molecules that are optically active. The first polaroid plane polarizes light. As the plane polarized light passes through the syrup, various wavelengths in the light source are rotated by different angles. Hence, we see different colours at different orientations of the two polaroids.

RESONANT RINGS

Objective: To show that rings of different radii respond at different frequencies

Experiment: Rings of different diameters are made out of thick paper. Care should be taken to make rings of equal width. The rings are then glued to cardboard and placed on a speaker that is connected to an oscillator. An oscillator produces a range of frequencies, we notice that rings of different radii respond with maximum vibration at different frequencies.

Reason: Every object is characterised by its natural frequency of oscillation- the resonant frequency. The resonant frequency of a ring depend on the radius of the ring. Larger the radius, lower is its natural frequency of oscillation. As the speaker vibrates at different frequencies, the rings vibrate the most when the oscillator frequency matches with the ring's natural frequency or its integral multiples.

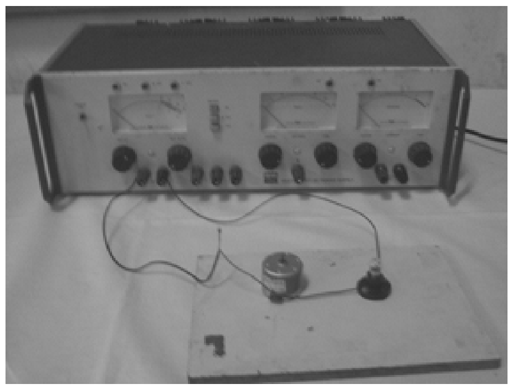
Singing Bowl

Objective: To show that sound can be produced by stick-slip motion

Experiment: Take a small bell - the kind that is used in temples - and remove the gong. Hold the 'stem' of the bell and gently stroke around the rim of the bell with a wooden rod. A continuous sound is heard.

Reason: The material as well as the shape of the bell helps in setting up the bell into vibrations. As we stroke the rim, the wooden rod makes and breaks contact with the surface. This is known as stick-slip motion. The squealing chalk while writing on the blackboard is also due to stick-slip motion. The frequency of the sound depends on the diameter of the bell.

Motor As A Dynamo



Objective: To illustrate that a motor produces an EMF

Experiment: Take a small DC motor and connect a 3v bulb in series with it. Connect the free ends of the motor and the bulb to a 5v dc supply. On switching the supply 'ON', we notice that the motor shaft begins to spin while the bulb is turned 'ON' at all!. Now, hold the shaft of the motor so that it does not rotate. The bulb glows brightly!

Reason: When the motor is running freely, that is, without any load, the current flowing through it is very small. Also, it begins to act like a dynamo, trying to drive current in the reverse direction to the current supplied. Much of the applied voltage manifests across the motor. The small fraction of voltage across the bulb is insufficient to cause it to glow. When the motor has a load, the armature turns slowly and the 'dynamo' effect is reduced. Consequently, the voltage across the motor reduces and the bulb glows.

Corn Flour Combustion

Objective: To show that the smaller the size of the particles, better is its combustion

Experiment: Light up a candle. When corn flour is sprinkled on the flame nothing unusual happens. Now, take the powder in the powder box and press it so that fine particles of powder are blown at the flame of the candle. The powder catches fire and the flame is dramatically carried through air for some distance!

Explanation: The vapours of wax consume lot of oxygen in the vicinity of the flame. So, the lumps of powder hardly get enough oxygen to burn. The moment we blow fine particles, each particle can catch fire with whatever little oxygen that is available. Also, the fine particles increase the effective area available.

Coefficient of Restitution

This is a dramatic display of collision and transfer of momentum. Consider a basketball and a tennis ball. If they are individually dropped from a height of about four feet, they reach a height of about two to three feet on bouncing back. Now, place the tennis ball on the basketball so that when the basketball is dropped, the tennis ball remains in contact with throughout the fall. As soon as the basketball hits the ground, the tennis ball flies off very fast and to a height several times the original one!

This is because the tennis ball acquires a greater velocity at the instant the basketball bounces back. Hence its kinetic energy also increases, taking it to a greater height.

Further Exploration: Will the basketball behave similarly, if it were placed above the tennis ball and the experiment repeated?

Calculate the increase in the velocity of the tennis ball.

Repeat the experiment with pairs of different balls.

Suppose the basketball and the tennis ball were to initially have a gap of about 3cm. Would the tennis ball now bounce back to same height? Explain your observation.